

On the identity and placement of *Xysticus lendli* Kulczyński, 1897 (Araneae, Thomisidae): an integrative approach

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Abstract

The species *Xysticus lendli* is known only from its original description of a single male and one doubtful record so far. Here, we illustrate and redescribe the species based on 34 specimens in total and describe its female for the first time. We illustrated the male palp via compound micrographs and scanning electron micrographs. We generated a DNA barcode and placed it into a current phylogenetic scaffold to confirm the species’ placement of *Spiracme*, a long-debated sister- or subgroup of *Xysticus*; hence, a new combination of *Spiracme lendli* (Kulczyński, 1897), **comb. nov.** is proposed. We illustrated the visually similar *Xysticus mongolicus* and the type species of *Spiracme*, *S. striatipes*, and compared them to *S. lendli* to aid future distinctions between those species.

Key Words

Central Europe, crab spiders, new combination, redescription, *Spiracme*

Introduction

Hungary has a rich arachnofauna, which has been well studied for a long time. Due to its unique location, glaciation history, and topological arrangement (the Carpathian Basin), numerous species have been described in this region. The Pannonian biogeographic region lies on a unique meeting point of various other biogeographic regions (Molnár et al. 2008; Fekete et al. 2016); for instance, the Eurasian steppe/forest steppe zone’s westernmost part is located here (Bátori et al. 2018). On the eastern part of Hungary, the forest steppe biome is present in the Kiskunság National Park, offering a unique opportunity to study the forest steppe biota (Gallé et al. 2022a) (Fig. 1A). The arachnofauna of Kiskunság National Park has been intensively studied due to the increased interest of ecologists and conservation biologists, who have conducted frequent studies in the last few decades (Gallé et al. 2022a, 2022b, 2022c, and references therein). During

these studies, several new species have been discovered (*Parasyrisca arrabonica* Szinetár & Eichard, 2009; *Sernokorba betyar* Gallé-Szpisjak et al., 2023), and a few other “forgotten” taxa have been rediscovered as well. One of these taxa is *Xysticus lendli* Kulczyński, 1897, an enigmatic thomisid that was known by a single male specimen and did not have a verified record besides its original description more than a century ago.

Xysticus has been the subject of several classification attempts in the past 50 or so years (see Lehtinen 2002; Jantscher 2002; and Breitling 2019 for details). Almost all of these papers used morphological data, whereas the last treatment by Breitling (2019) used the phylogeny of barcode sequences alone. One main result of the latter was the resurrection of the genus *Spiracme* Menge, 1876, with the type species *Spiracme striatipes* (L. Koch, 1870) and including nine other species: *Spiracme baltistana* (Caporiacco, 1935), *Spiracme dura* (Sørensen, 1898), *Spiracme keyserlingi* (Bryant, 1930), *Spiracme lehtineni*

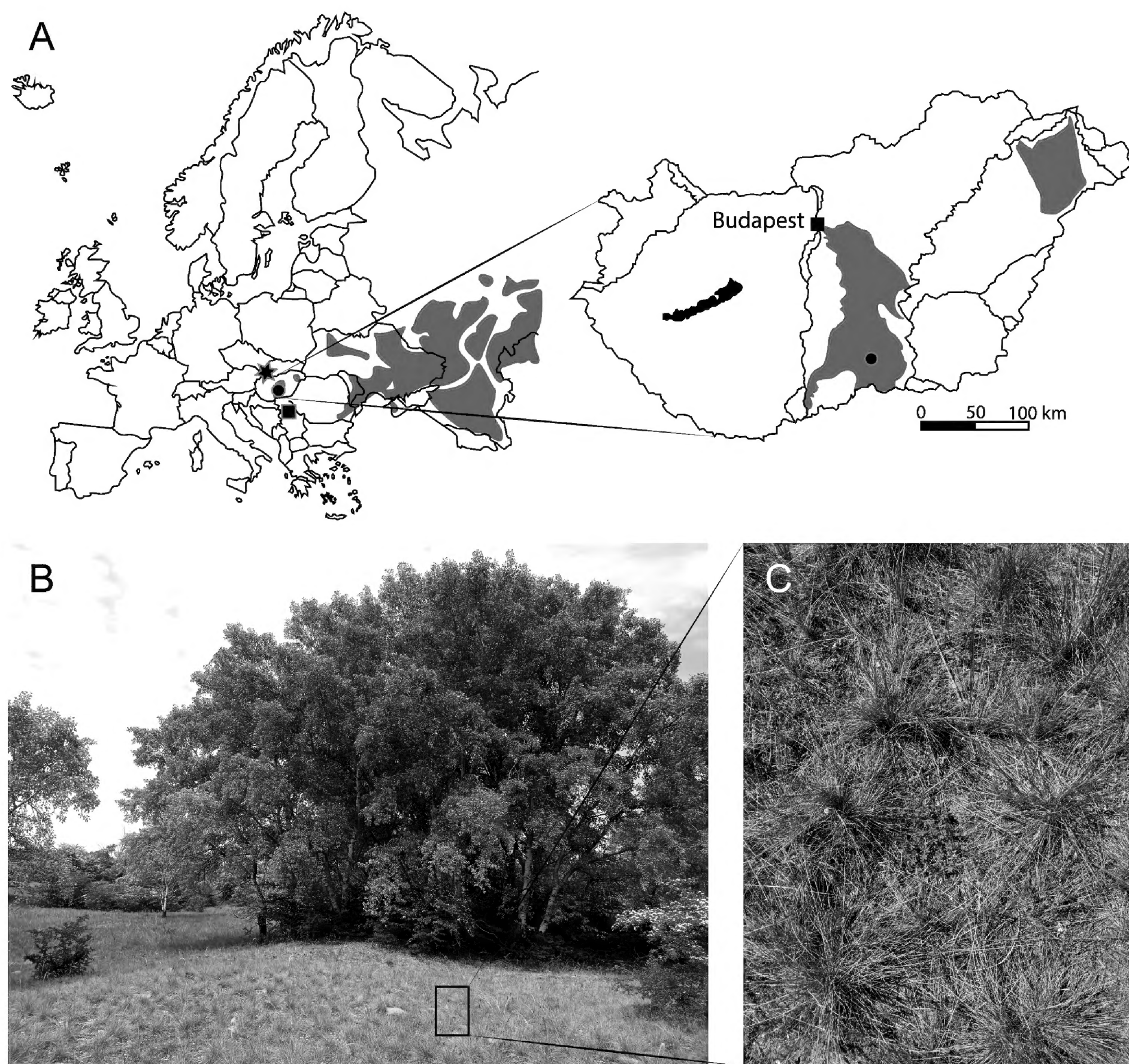


Figure 1. A. Map of Europe and Hungary with the forest-steppe zone (green patches), the Hungarian sampling site (black circle), the Slovakian sampling site (black star, Purgat et al. 2021), and the Serbian sampling site (black square, Grbić et al. 2019); B. Forest-steppe patch; C. Open sand grassland.

(Fomichev, Marusik & Koponen, 2014), *Spiracme nigromaculata* (Keyserling, 1884), *Spiracme quadrata* (Tang & Song, 1988), *Spiracme triangulosa* (Emerton, 1894), *Spiracme vachoni* (Schenkel, 1963). Later, Purgat et al. (2021) added *Spiracme mongolica* (Schenkel, 1963) to the genus.

While identifying our specimens, we noticed that the palp shows a high overall similarity to that of *S. mongolica*, as illustrated by Purgat et al. (2021). Still, at the same time, significant differences could be observed between the illustrations of the original description of Schenkel (1963) and the specimen identified and pictured by Fomichev (2015).

The aims of this paper are to provide illustrations and a description for *Xysticus lendli* Kulczyński, 1897, based on freshly collected material, describe the hitherto

unknown female of the species, and reevaluate current faunistic records that may involve this species. We provide a DNA barcode for the species and test its phylogenetic position by reanalysing the matrix of Breitling (2019) with this new sequence added, and we discuss the accompanying results using a comparison with the type species of *Spiracme*.

Materials and methods

Specimens were collected in the Kiskunság region, Hungary, in 2017, 2018, and 2021 by sweep net from semi-natural sandy forest steppe patches (Fig. 1B, C). The specimens were photographed with a Nikon D300S camera attached to a Nikon S800 stereomicroscope and a Tucsén

Truechrome Metrics camera attached to an Eclipse E200 compound microscope. Multifocal images were compiled using HeliconFocus. The female vulva and palps in Fig. 5 were illustrated while immersed in methyl salicylate. Scanning electron micrographs were made in a low vacuum on a Hitachi SV1000 FlexSEM scanning electron microscope in the Plant Protection Institute (NÖVI) HUN-REN Centre for Agricultural Research. Drawings were made by the first author using a fineliner and 80 g/m² of printing paper. The maps were made using Adobe Illustrator CS6 software. All measurements are given in millimetres. The material is deposited in the Museum of Natural History, Budapest (MNHB) and the first author's personal collection in Szeged.

Whole genomic DNA was extracted from one leg using standard extraction kits. For the barcoding, the LCO1940/HCO2198 primers (Folmer et al. 1994) were used. PCR has been carried out in the Department of Zoology of the University of Veterinary Medicine Budapest, and capillary electrophoresis has been done at Commercial Biomi Services (Gödöllő, Hungary). Sequences were edited using Gap4 of the Staden Package (Staden et al. 2000) and deposited in GenBank with the accession number PP545308. Phylogenetic relationships were inferred via both maximum likelihood and Bayesian methods based on the dataset that has been published so far (Breitling 2019). MAFFT v.7.450 online (<https://mafft.cbrc.jp/alignment/server/>) was used with default settings to align the sequences. A maximum likelihood phylogram was constructed using IQ-TREE (Nguyen et al. 2015) under the GTR+F+I+G model, performing 1000 ultrafast bootstrap replicates. Bayesian inference was performed using MrBayes v. 3.2.6 (Ronquist and Huelsenbeck 2003), using the GTR+I+G model of sequence evolution. Analyses consisted of two independent runs with one cold chain and five hot chains from random starting trees, run for 10 million generations, and sampled every 1000 generations. Convergence was assessed through examination of the standard deviation of split frequencies, which was well below recommended thresholds (0.01). The two MrBayes runs were combined after the deletion of burn-in generations (25%), and a majority-rule consensus phylogram was created. The resulting phylograms were edited and visualised with FigTree v.1.4 (Rambaut 2014).

Abbreviations

ALE — Anterior lateral eyes; **AME** — Anterior median eyes; **Fe** — Femur; **MOA-WA** — width of anterior median ocular area; **MOA-L** — median ocular area length; **MOA-WA** — width of anterior median ocular area; **MOA-WP** — width of posterior median ocular area; **Mt** — Metatarsus; **PLE** — Posterior lateral eyes; **PME** — Posterior median eyes; **RTA** — Retrolateral tibial apophysis; **Ta** — Tarsus; **tb** — tegular bump; **Ti** — tibia; **tut** — tutaculum; **VTA** — Ventral tibial apophysis.

Results

Taxonomy

Spiracme Menge, 1876

Figs 2, 3A–C, G–I, 4A–C, 5A, B, 6–8

Type species. *Spiracme striata* Menge, 1864. *Xysticus striata* Menge, 1876, by monotypy.

Note. Breitling (2019) revalidated the genus *Spiracme*, but he did not provide any diagnosis or any diagnostic features. As delimited by Breitling (2019), it is impossible to give a precise diagnosis for the genus, including all and only those species. Hence, it should be subject to future revision or reconsideration.

Diagnosis. Males can be recognised by the bulb lacking apophyses (Fig. 6A, D) or tegular apophysis (Gertsch 1953; Menge 1876; Lehtinen 2002). The tutaculum is triangle-shaped in this type of species. Tibia with two or three apophyses; VTA is simple and rounded; and RTA has a distinct pointed hook (Lehtinen 2002). Females can be recognised by the prominent septum (but can be absent; see Gertsch 1953). Both sex lateral eyes are 1.5 times larger than the median eyes and have light elevation (Menge 1876).

Composition. Currently 10 species have been added to this genus (WSC 2024): *S. striatipes* (L. Koch, 1870), *S. baltistana* (Caporiacco, 1935), *S. dura* (Sørensen, 1898), *S. keyserlingi* (Bryant, 1930), *S. lehtineni* (Fomichev, Marusik & Koponen, 2014), *S. nigromaculata* (Keyserling, 1884), *S. quadrata* (Tang & Song, 1988), *S. triangulosa* (Emerton, 1894), *S. vachoni* (Schenkel, 1963).

Description. see Menge (1876) and Lehtinen (2002).

Distribution. Holarctic.

Spiracme lendli (Kulczyński, 1897), comb. nov.

Figs 2, 3A–C, 4A–C, 5A, B, 6A–C, 7, 8

Xysticus lendli Kulczyński, 1897: Chyzer and Kulczyński 1897: 301, Tab X, fig. 64 (♂).

Spiracme mongolica: Purgat et al. 2021: fig. 6 (misidentification).

Xysticus cf. lendli: Ponomarev and Shmatko 2021: 217, fig. 16.

Type material. *Holotype male*: HUNGARY Örkény (thoroughly searched for in the collection of the Hungarian Natural History Museum, without any success, likely lost).

Material examined. HUNGARY • 1 male; Szank; forest steppe; 46.602°N, 19.571°E; 11 Sep. 2017; N. Gallé-Szpisjak and R. Gallé leg.; sweep net; (HNHM Araneae-11039) • 1 female; Zsana; forest steppe; 46.415°N, 19.621°E; 11 Sep. 2017; N. Gallé-Szpisjak and R. Gallé leg.; sweep net; (HNHM Araneae-10719) • 1 male; Harkakötöny; forest steppe; 46.507°N, 19.568°E; 11 Sep. 2017; N. Gallé-Szpisjak and R. Gallé leg.; sweep net • 2 males; Kiskunhalas; forest steppe; 46.477°N, 19.432°E; 11 Sep. 2017;

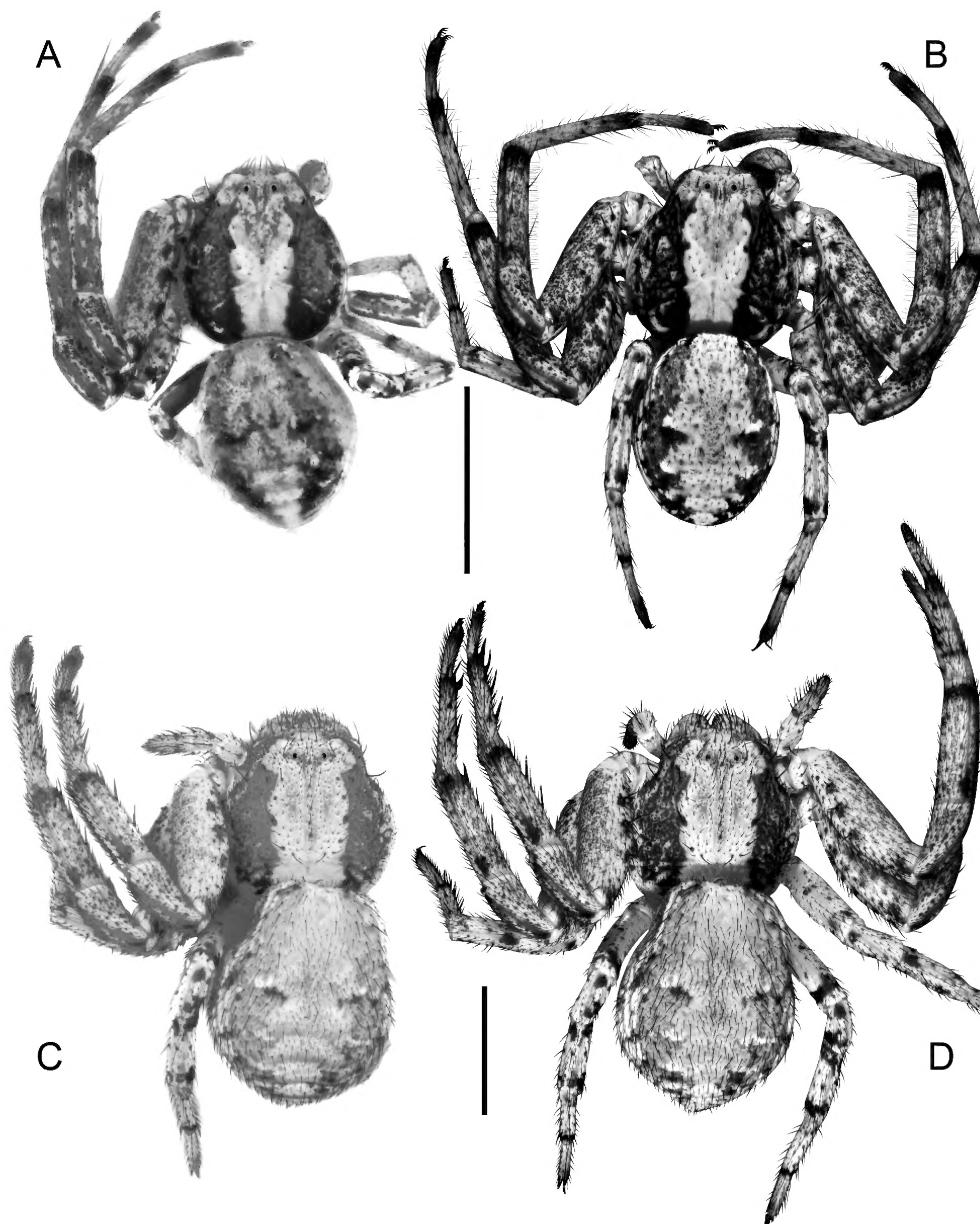


Figure 2. Habitus of *Spiracme lendli*: **A, B.** Male; **C, D.** Female; **A, C.** Specimen in alcohol, bleached out; **B, D.** Fresh specimens; Scale bar: 2.0 mm.

N. Gallé-Szpisjak and R. Gallé leg.; sweep net • 3 males; Kiskunhalas; forest steppe; 46.483°N, 19.452°E; 09 Sep. 2018; N. Gallé-Szpisjak and R. Gallé leg.; sweep net • 2 males; Kiskunhalas; forest steppe; 46.493°N, 19.415°E; 21 Sep. 2018; N. Gallé-Szpisjak and R. Gallé leg.; sweep net • 1 male; Soltvadkert; forest steppe;

46.536°N, 19.384°E; 11 Sep. 2017; N. Gallé-Szpisjak and R. Gallé leg.; sweep net • 1 male; Soltvadkert; forest steppe; 46.527°N, 19.374°E; 11. Sep. 2017, N. Gallé-Szpisjak and R. Gallé leg.; sweep net • 3 males; Soltvadkert; forest steppe; 46.530°N, 19.401°E; 11. Sep. 2017, N. Gallé-Szpisjak and R. Gallé leg.; sweep net • 3 males;

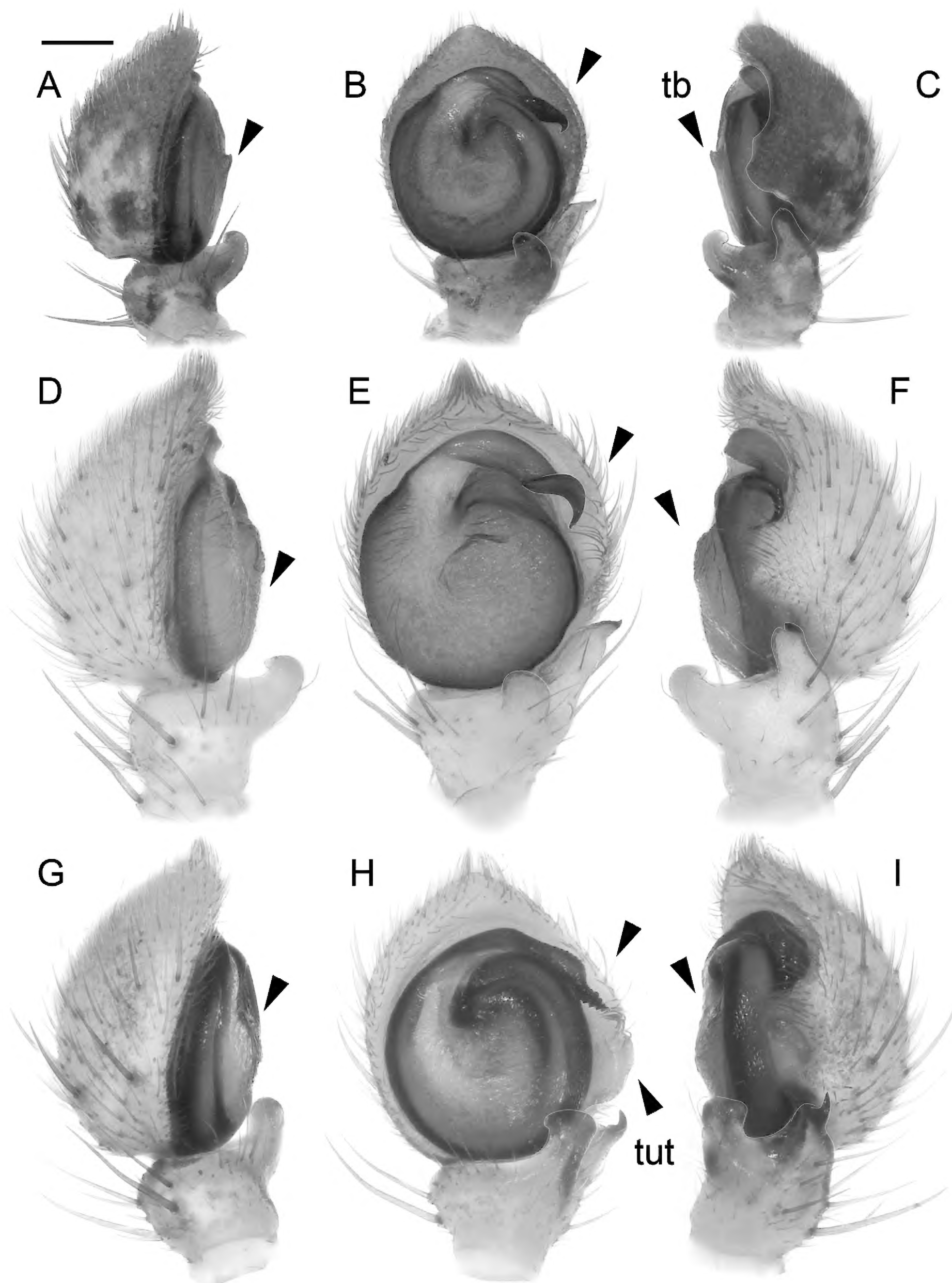


Figure 3. Male palps: **A–C.** *Spiracme lendli*; **D–F.** *Xysticus mongolicus*; **G–I.** *S. striatipes*; **A, D, G.** Prolateral view; **B, E, H.** Ventral view; **C, F, I.** Retrolateral view. Scale bar: 0.2 mm. Abbreviations: tb — tegular bump; tut — tutaculum.

Soltvadkert; forest steppe; 46.532°N, 19.385°E; 21. Sep. 2018, N. Gallé-Szpisjak and R. Gallé leg.; sweep net • 1 male; Zsana; forest steppe; 46.409°N, 19.621°E; 11. Sep.

2017, N. Gallé-Szpisjak and R. Gallé leg.; sweep net • 3 males; Zsana; forest steppe; 46.415°N, 19.621°E; 09. Sep. 2018, N. Gallé-Szpisjak and R. Gallé leg.; sweep net

• 3 males; Zsana; forest steppe; 46.396°N, 19.647°E; 09. Sep. 2018, N. Gallé-Szpisjak and R. Gallé leg.; sweep net
 • 2 males; Imrehegy; forest steppe; 46.446°N, 19.318°E; 11. Sep. 2017, N. Gallé-Szpisjak and R. Gallé leg.; sweep net
 • 1 male; Pirtó; forest steppe; 46.493°N, 19.415°E; 20. Sep.–05. Oct. 2018, N. Gallé-Szpisjak and R. Gallé leg.; pitfall trap
 • 1 male; Pirtó; forest steppe; 46.472°N, 19.436°E; 09. Sep. 2018, N. Gallé-Szpisjak and R. Gallé leg.; sweep net
 • 4 males; Pirtó; forest steppe; 46.496°N, 19.421°E; 05. Oct. 2018, N. Gallé-Szpisjak and R. Gallé leg.; sweep net
 • 2 males; Bócsa; forest steppe; 46.614°N, 19.464°E; 07. Sep. 2021, N. Gallé-Szpisjak and R. Gallé leg.; sweep net.

Comparative material. *S. striatipes* HUNGARY • 2 males, 2 females; Csengőd; mesic grassland; 46.722°N, 19.350°E; 15 Jun. 2018; N. Gallé-Szpisjak and R. Gallé leg.; sweep net.

Diagnosis. Males of this species can be readily distinguished from congeners by the thick and bent embolus, with transverse ridges (pine cone-like pattern in Fig. 5A–B) near the tip. The thick embolus makes it similar to that of *S. striatipes* but differs by the bent embolus (straight in *S. striatipes*; see Figs 3, 4), the less pronounced indentations (deep indentations in *S. striatipes*; see Fig. 6), the absence of the large triangular-shaped tutaculum (present in *S. striatipes*; see Fig. 6), and the slightly pointing outward RTA (curved towards the cymbium in *S. striatipes*; see Figs 3, 4) as seen from the ventral side (compare Fig. 6A vs. Fig. 6D). The bent embolus is present in *Xysticus mongolicus*, and the bulb shows an overall similarity. However, the indentations (absent in *X. mongolicus*), the tegular bump Fig. 3C (absent in *X. mongolicus*; see Fig. 3F), and the twisted embolus as seen from the side (strongly bent in *X. mongolicus*) separate *S. lendli* from *X. mongolicus*. Female epigyne of *S. lendli* with an upside-down heart-shaped median septum (see Fig. 8B), which is seemingly a plate with a pronounced anterior border (Fig. 8A, C) with a clear indentation on the posterior margin (Fig. 8B, C, F), probably to accommodate the thin tip of the RTA (Figs 3C, 7A).

Description. Male. Total length 3.88. Carapace: 1.84 long, 1.79 wide. Abdomen: 2.17 long, 1.71 wide. Clypeus 0.16 high, chelicera 0.70 long. Eye sizes and inter-distances: MOA-WA 0.22, MOA-WP 0.23, MOA-L 0.23, AME 0.07, ALE 0.10, PME 0.06, PLE 0.09, AME-AME 0.20, AME-ALE 0.13, PME-PME 0.23, PME-PLE 0.29.

Colouration (on a freshly collected specimen, Fig. 2B): Carapace dark brown sides with median, longitudinal, beige-coloured, wide stripe. Ocular area white. Abdomen dark brown with mottled black spots and median folium-shaped light stripe. Around folium's lobe, three pairs of white and black spots present (Fig. 2A, B). These spots can be seen on bleached specimen as well, where the dark brown coloured areas became light brown. Chelicera, gnathocoxae, labium, and sternum sand-yellow with small dark brown spots.

Legs: sand-yellow with mottled dark brown dots (uneven in size). Tibiae I–II, metatarsi I–II, and tarsi I–II with dark

brown/blackish rings on the distal end of the segment. Hind-legs light in colour, almost white, with black dots mottled on the appendage. The proximal end of tibia IV and the distal end of the femur, patella, tibia, and metatarsus IV with dark rings. Leg segments: I: 7.05 (2.04+0.96+1.6+1.6+0.85); II: 6.67 (1.95+0.88+1.45+1.48+0.91); III: 3.87 (1.19+0.58+0.83+0.67+0.6); IV: 4.51 (1.4+0.58+0.92+0.89+0.72).

Palpal femur, patella tibia, and cymbium with sand-coloured background mottled with dark brown dots and patches. Bulb without significant appendages, but tegular ledge or bump present (Figs 3C, 4C, 7A). Embolus originates on prolateral part of the bulb at 11 o'clock position, twisted as seen from the side (Fig. 7) and bent as seen from the venter (Figs 3A–C, 4A–C, 5A, B), with indentations on the distal third of embolus (Figs 5A, B, 6A, B), making it pine cone-like.

Female. Total length: 5.99. Carapace: 2.66 long, 2.89 wide. Abdomen: 3.68 long, 2.92 wide.

Clypeus 0.24 high, chelicera 1.01 long. Eye sizes and inter-distances: MOA-WA 0.58, MOA-WP 0.53, MOA-L 0.40, AME 0.11, ALE 0.16, PME 0.09, PLE 0.12, AME-AME 0.40, AME-ALE 0.21, PME-PME 0.37, and PME-PLE 0.45. Leg segments: I: 8.49 (2.61+1.34+1.87+1.7+0.97); II: 8.49 (2.65+1.24+1.84+1.77+0.99); III: 5.53 (1.76+0.91+0.93+1.05+0.88); IV: 6.16 (1.94+0.88+1.44+1.07+0.83).

Colouration lighter than in males, carapace and abdomen patterns similar as in males (Fig. 2C, D), but with less contrast on the pattern. Leg colouration and pattern also similar to males, but overall lighter in colour.

Distribution. Pannonian: Hungary, Serbia, Slovakia.

Habitat. Specimens were collected in habitats characterised by sandy soil, covered with open dry grassland, and small forest patches (forest steppe, Fig. 1B, C). The grassland consists of drought-tolerant plant species (e.g., *Alkanna tictoria*, *Festuca vaginata*, and *Stipa borysthénica*). The main tree species of the forest patches are *Populus alba*, and the bush layer includes *Juniperus communis* and *Crataegus monogyna* (see further details in Gallé et al. 2022a).

Biology and phenology. Adult specimens were collected in September and October. We used a sweep net to collect *S. lendli* specimens very close to the ground surface in the herb layer. Life history remains mainly unknown. Noteworthy, females were very rarely found, so far only one. The overall ratio of the sexes was 33:1.

Xysticus mongolicus Schenkel, 1963, comb. rev.

Figs 3D–F, 4D–F, 5C, D

Xysticus mongolicus Schenkel, 1963: Schenkel 1963: 227, fig. 127a–c (♂).
X. mongolicus Song, Yu & Yang, 1982: 210 (♂♀); Song 1987: 284, fig. 241a–d (♂♀); Song and Zhu 1997: 95, fig. 62a–d (♂♀); Utochkin 1995: 67, fig. 1a–g (♂♀); Zhao 1993: 388, fig. 193a–b (♂♀); Marusik and Logunov 1990: 47, figs 48–49 (♂); Fomichev 2015: 97, figs 13–15 (♂).

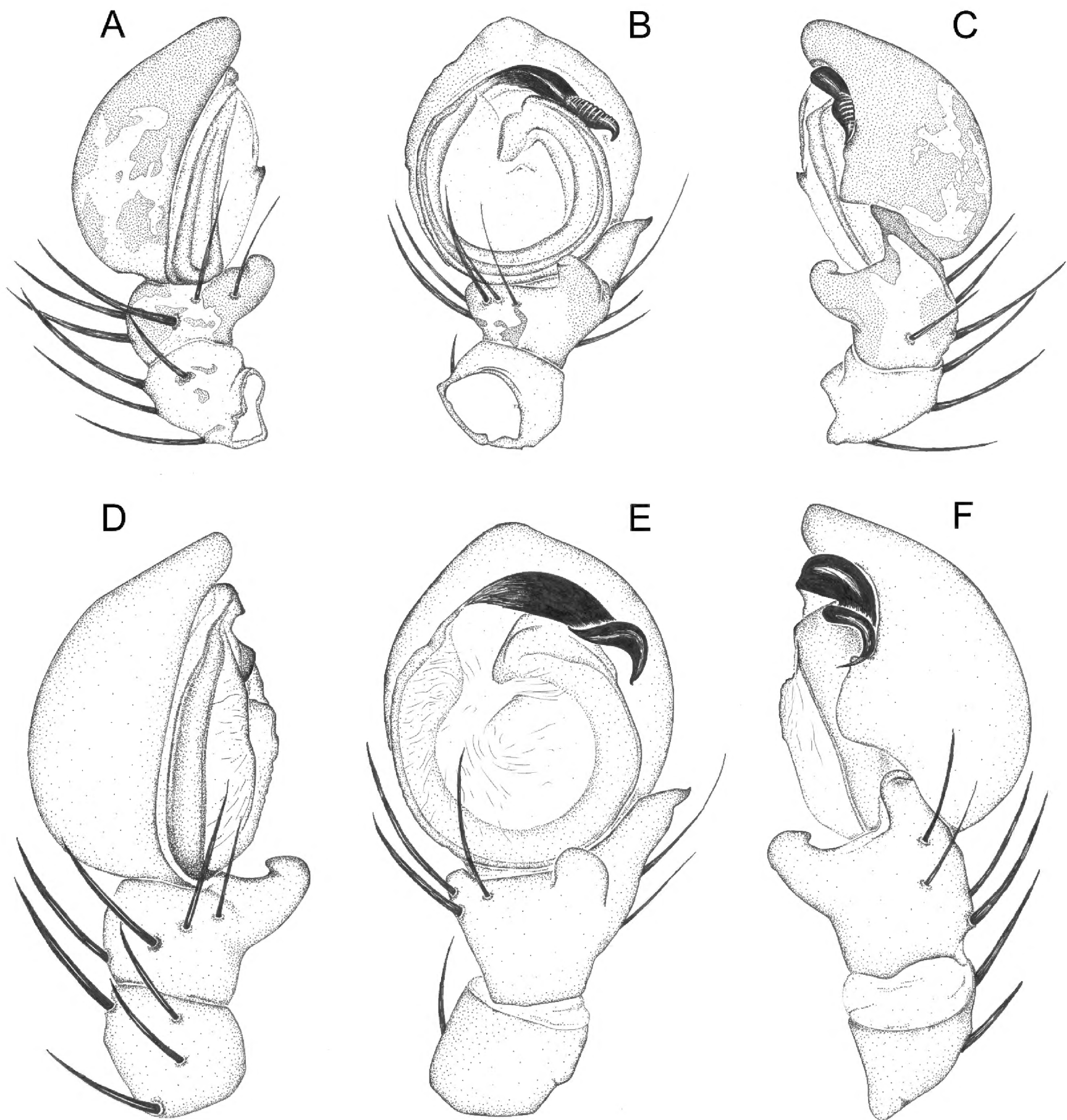


Figure 4. Distinguishing characters of *Spiracme lendli* (A–C) and *Xysticus mongolicus*: (D–F); D. Prolateral view; B, E. Ventral view; C, F. Retrolateral view. Scale bar: 0.2 mm.

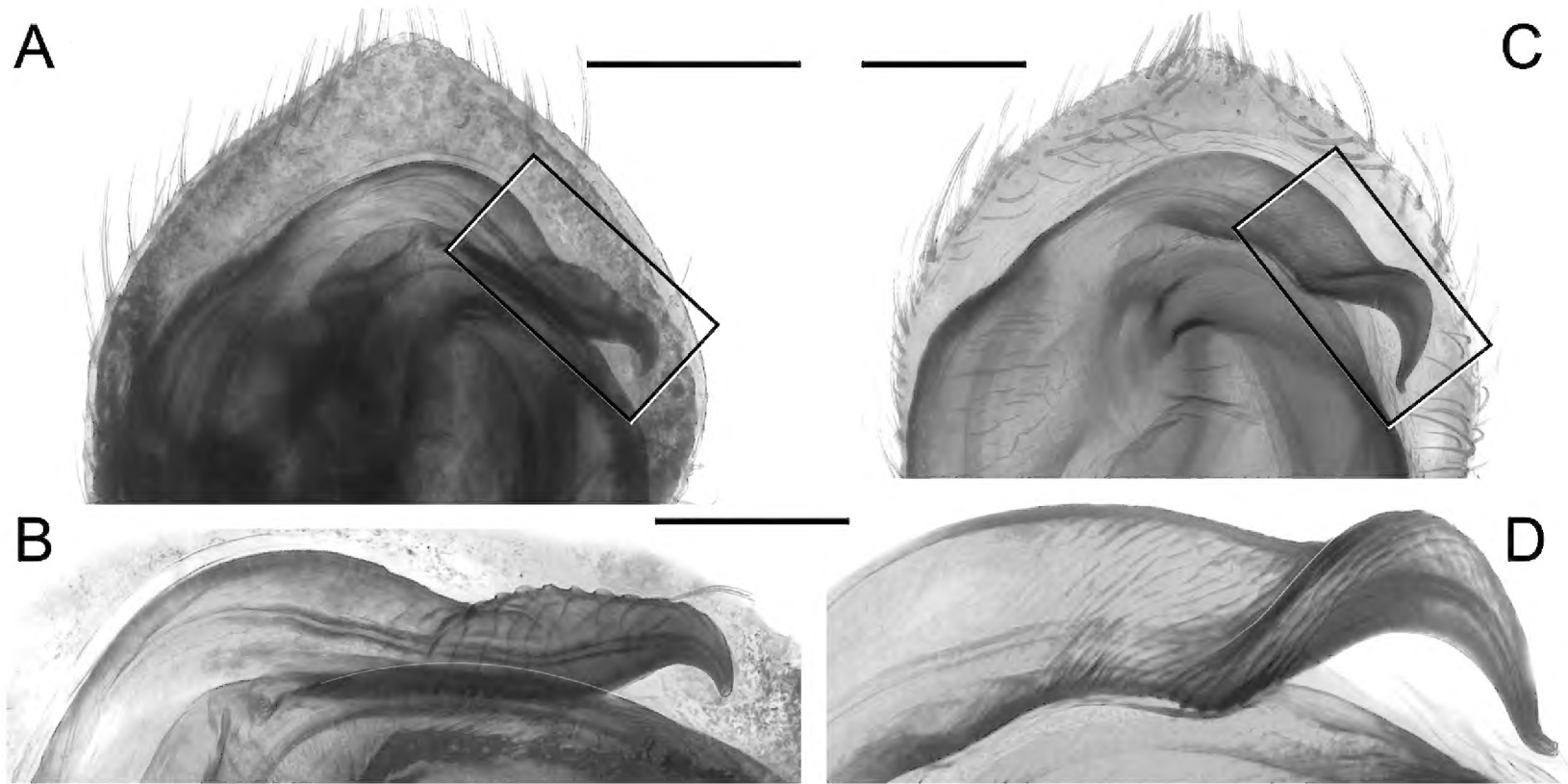


Figure 5. Comparison of male emboluses: *Spiracme lendli* (A, B) and *Xysticus mongolicus* (C, D). Scale bars: 0.2 mm.

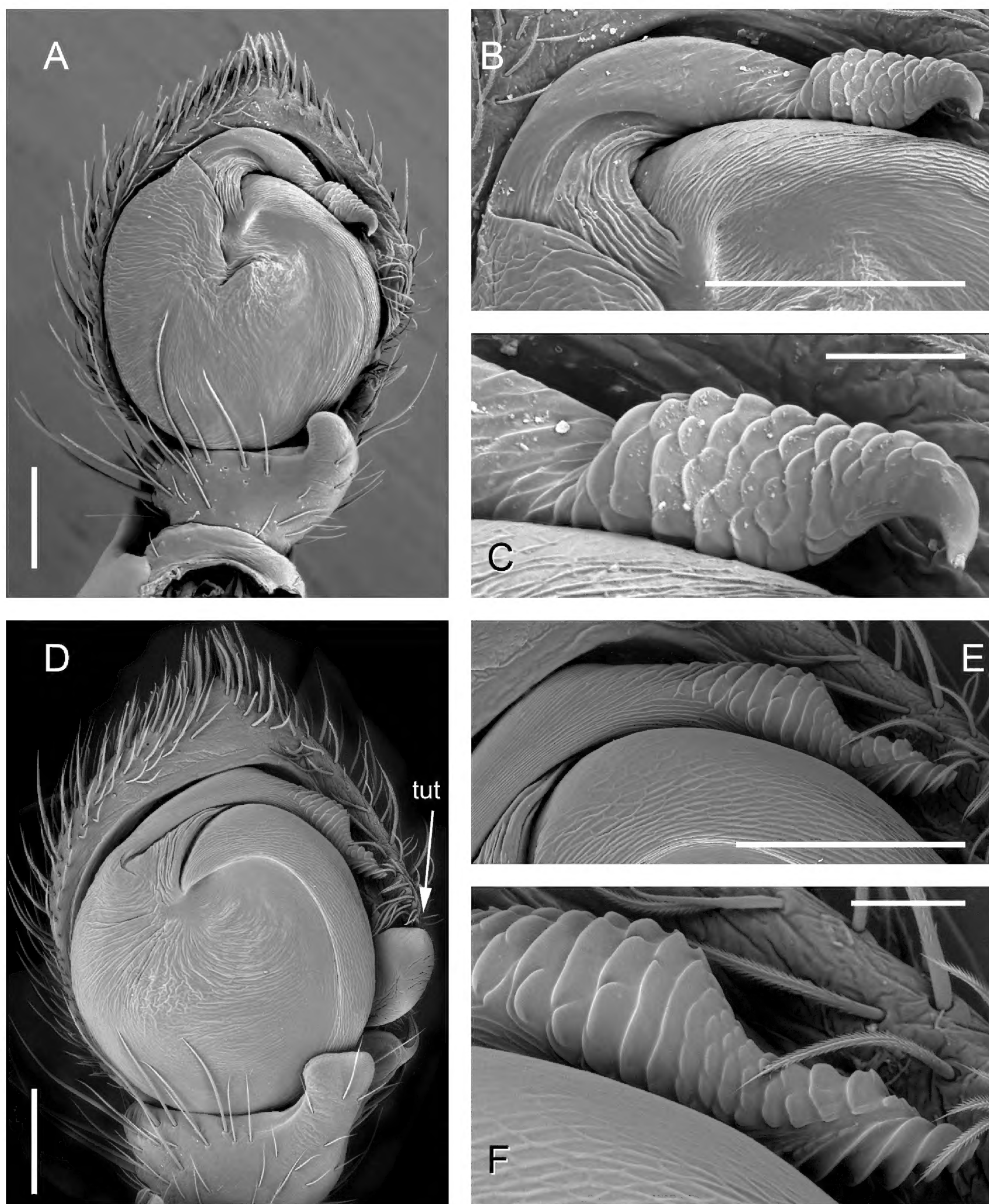


Figure 6. *Spiracme* spp. Male palps scanning micrographs *Spiracme lendli*: (A–C) *Spiracme striatipes*: (D–F); **A.** Bulb, ventral view; **B, C.** Closeup of the embolus, ventral view; **D.** Bulb, ventral view; **E, F.** Closeup of the embolus, ventral view. Scale bar: 0.2 mm (A–B, D–E); 0.05 mm (C, F). Abbreviation: tut — tutaculum.

Note. Because Purgat et al. 2021 (fig. 6) based their proposal of the new combination on a misidentified *S. lendli* specimen, we reinstate its original combination.

Material examined. RUSSIA • 1 male (ISEA, 001.7306), RUSSIA, Altai Republic, 6 km SE of Chagan-Uzun Vill., 26.07.2021. 50.066667°N, 88.433333°E, 1900 m asl., stony semi-desert steppe, leg. & det. A.A. Fomichev.: Altai Republic,

Diagnosis. The male can be identified by the spiral-shaped and bare embolus with fine tip. *X. mongolicus* has no tegular ridge.

Description. See Fomichev, 2015.

Distribution. Nentwig et al. (2024) report this species from Europe to Central Asia. So far, all Central European records have turned out to be *S. lendli*. We could not examine the specimens used for the Ukrainian records by Polchaninova N., Prokopenko E. (2019), or the Russian records (Ponomarev 2022).

Both ML and BI phylogenetic trees (Fig. 9, Suppl. material 1, respectively) place *Spiracme lendli* grouping with the type species of the genus, *S. striatipes*. In that group, *S. triangulosus* is a sister. We were unable

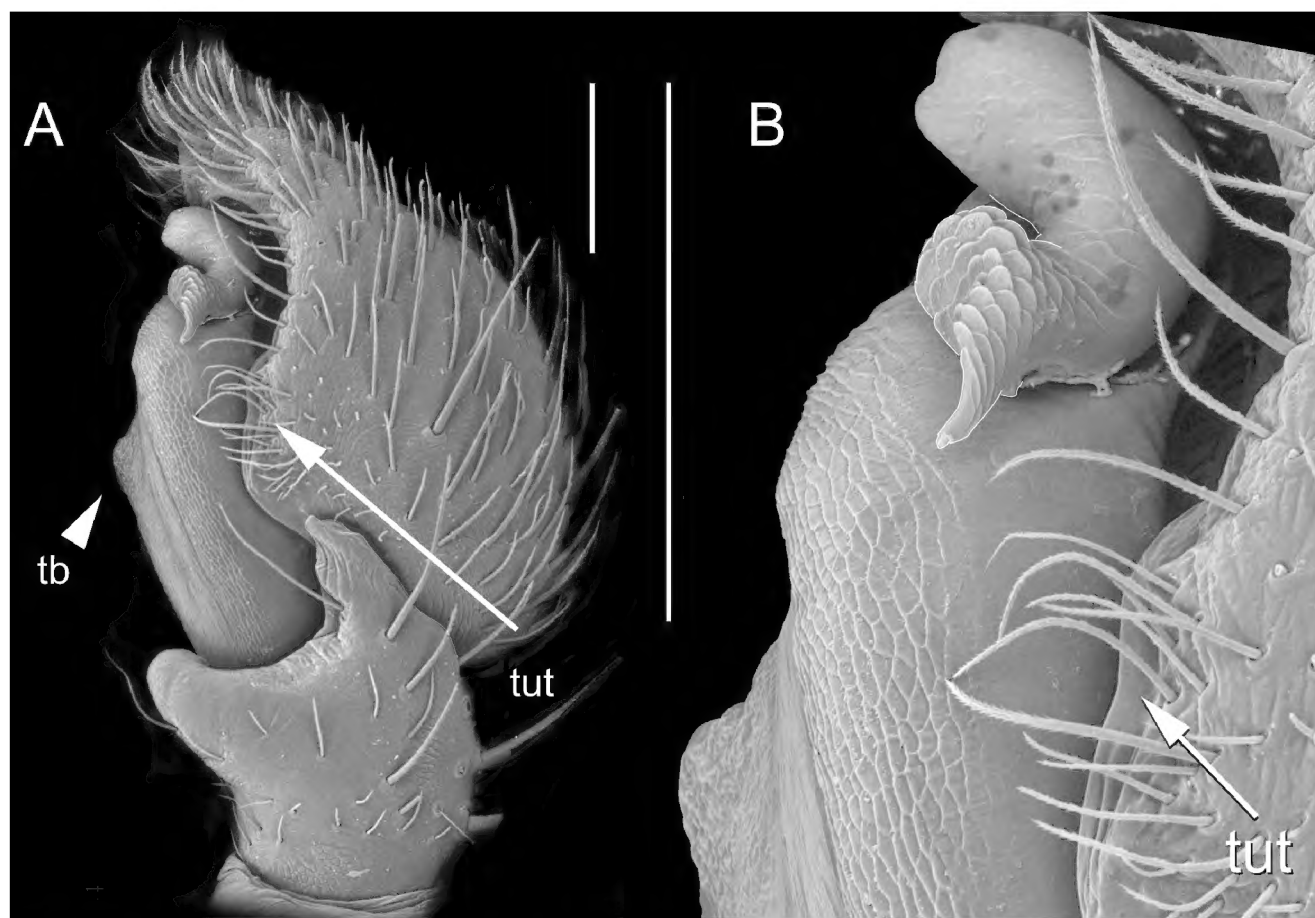


Figure 7. *Spiracme lendli*, male palps scanning micrographs: **A.** Entire palp retrolateral view, male; **B.** Bulb closeup, showing the embolus, the tegular bump, and the tutaculum. Scale bars: 0.2 mm. Abbreviations: tb — tegular bump; tut — tutaculum.

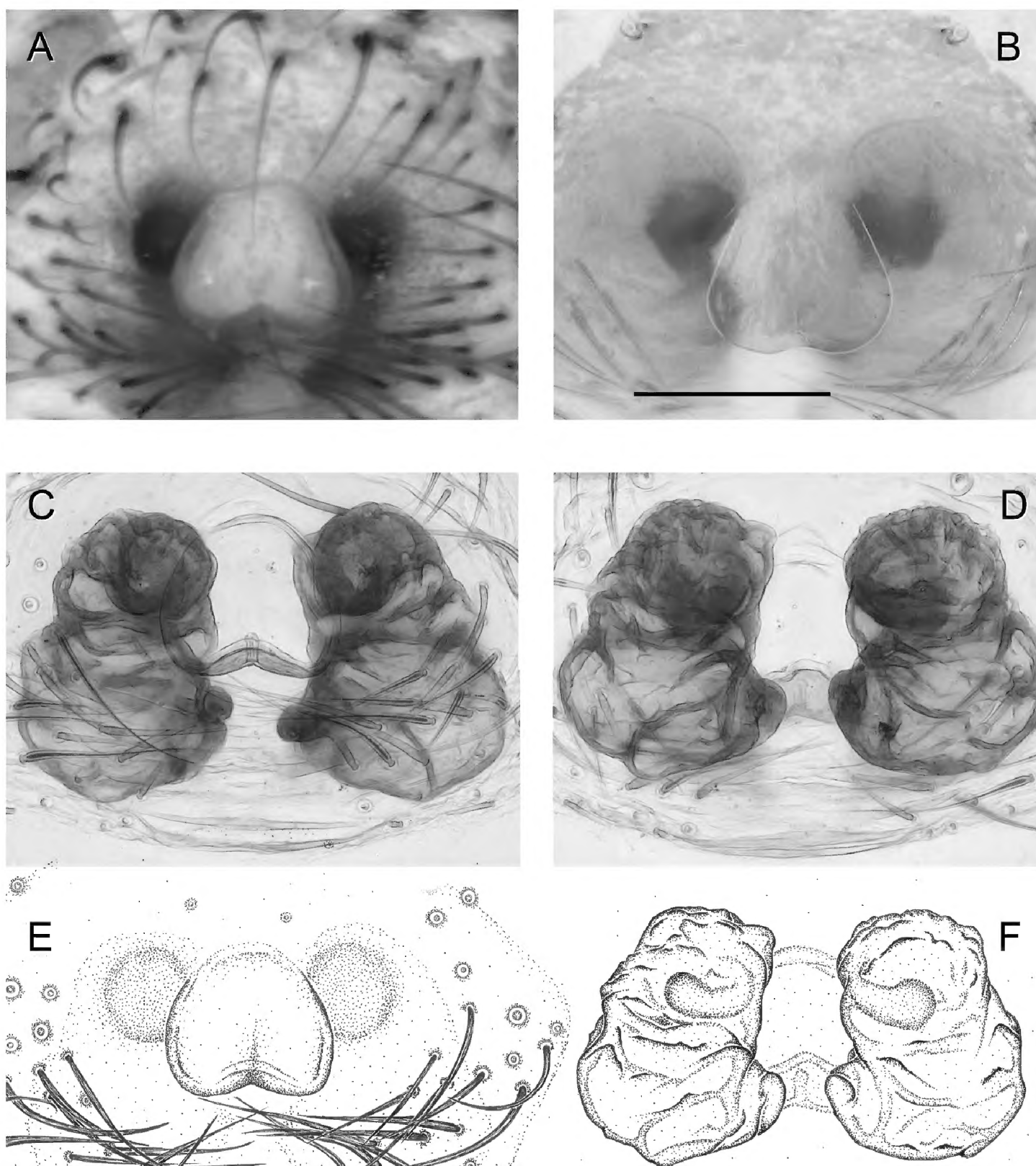


Figure 8. *Spiracme lendli* epigyne **A.** Fresh specimen, intact epigyne, ventral view; **B.** Prepared epigyne, ventral view; **C.** Same, in wintergreen oil; **D.** Vulva, dorsal view; **E.** Epigyne, ventral view; **F.** Vulva, dorsal view. Scale bar: 0.2 mm.

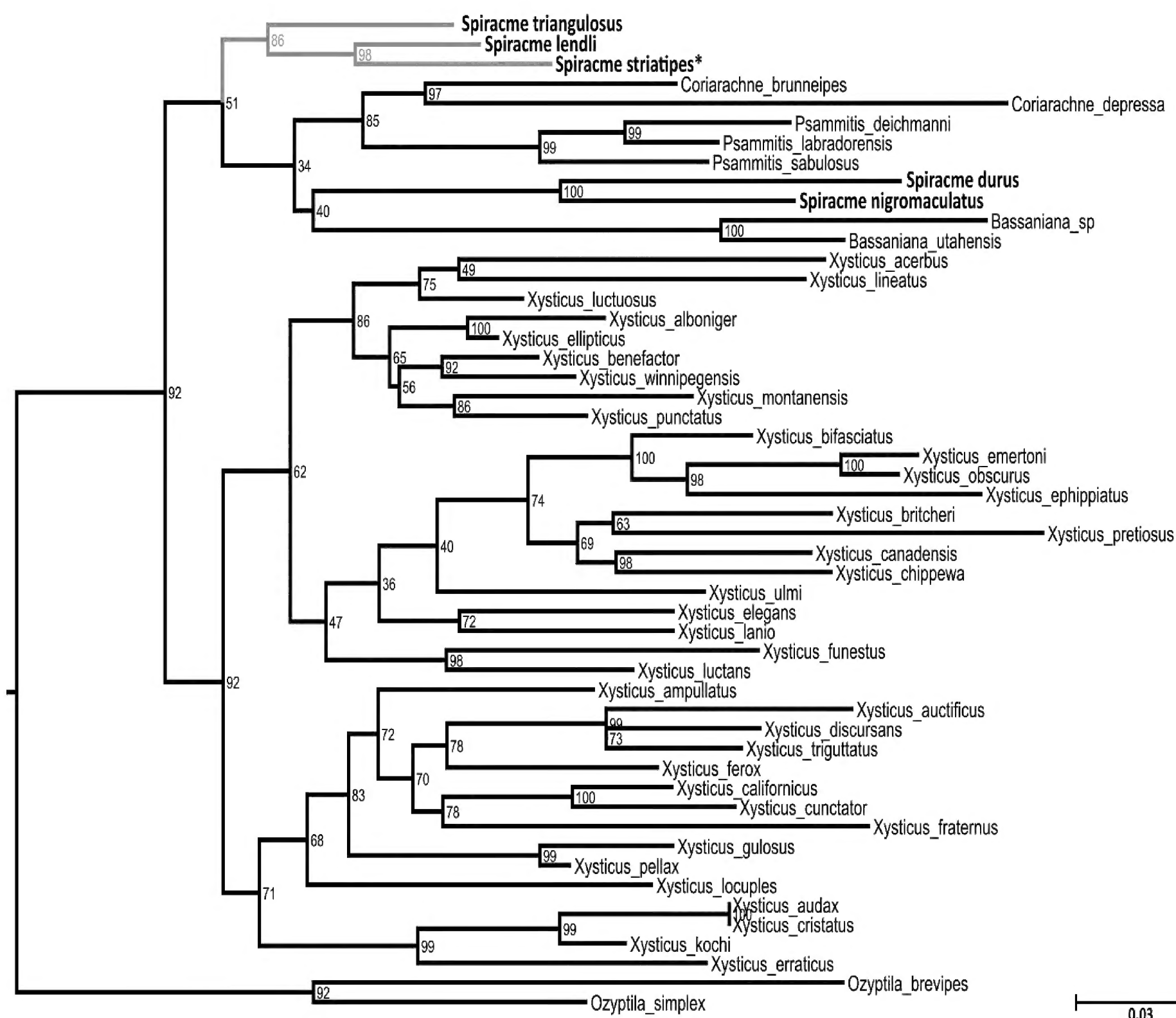


Figure 9. Maximum likelihood tree based on the DNA barcode data (658 nt of the mitochondrial COX1 gene), inferred with IQ-TREE.

to recover a monophyletic *Spiracme*, as *S. durus* and *S. nigromaculatus* grouped together but not with the type species. Given the limited use of a single mitochondrial gene in systematics and the low support values on the tree, we would not draw further conclusions regarding the genus limits.

Discussion

With the revalidation of *Spiracme*, perhaps Pandora's box has been opened. As it stands, the genus contains other species groups (*durus* and *nigromaculatus*). From the original description of the genus erected for *S. striatipes* (L. Koch, 1870) by Menge (1876), it is now clear that he not only specifically listed the unique shape of the embolus of the type species ("spitze schraubenförmig gewundenen eindringer" [=embolus spirally twisted]) as diagnostic, but the etymology is also based on the spirally twisted embolus ("spira and cuspis... Von der schraubenförmigen spitze des eindringers") as well. We assume that the genus concept of the auctor was to include species with spirally twisted emboli on top of an anapophysate

tegulum. In the genus, as delimited currently by Breitling (2019), most of the species have filiform emboli and various tegular outgrowths. Considering all available information, including any species with filiform embolus in the genus *Spiracme*, on the basis of DNA barcode data alone might have been premature.

Menge erected another genus, *Psammitis* Menge, 1876, of which at least the type species, *Psammitis sabulosus* (Hahn, 1832), has a similar indentation on the embolus (Jantscher 2001). There is little to no consensus among the plethora of opinions regarding the limits and placement of *Spiracme* or *Psammitis*. However, placing *Spiracme lendli* based on morphology alone provides a challenge. It does not have a prominent tutaculum (Figs 3, 4, 7) versus *Spiracme striatipes*, which has a large, prominent triangular one (Figs 3H, 4H), and the tutaculum of *Psammitis* species is thin and points upward. *Spiracme lendli* has indentations on the bent embolus (Figs 5–7), *S. striatipes* has deeper indentations and a straight embolus; *P. sabulosus* has weaker indentations and a bent embolus; and finally, *S. lendli* has a tegular pocket similar to *P. sabulosus*, which is absent in *S. striatipes* (Figs 3I, 4I). Due to the inconsistent distribution of the

morphological characters used to place species into these genera, we decided to use the grouping with the type species of *Spiracme* and place *Xysticus lendli* Kulczyński, 1897, to *Spiracme* Menge, 1876.

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Supplementary material 1

BI phylogram based on the barcode COI dataset (657 bp), inferred with MrBayes 3.2

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Data type: jpg

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